Original Article

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Clinical investigation of effects of eldecalcitol on lipid profile and other metabolic parameters in osteoporosis-treatment-naïve postmenopausal women with osteoporosis

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SUMMARY: Osteoporosis is characterized by decreased bone mass and disruption of bone architecture. Eldecalcitol is the newest analog of activated vitamin D that can improve osteoporosis. In addition, dietary/activated vitamin D can improve metabolic parameters. Clinical studies have shown that activated vitamin D analogs improve glucose tolerance and hepatic function. However, the effects of activated vitamin D analogs, including eldecalcitol, on lipid parameters are yet to be clinically investigated. We aimed to reveal the effects of eldecalcitol on lipids and other metabolic parameters for 24 weeks in 54 osteoporosis-treatment-naïve postmenopausal women with osteoporosis. We measured metabolic parameters before and 24 weeks after administration of eldecalcitol (0.75 μg per day) without changing the patients' other medications. All patients completed the study without complications, and T-scores (lumbar spine and femoral neck) significantly improved from baseline to 24 weeks after eldecalcitol administration (each $P < 0.001$). Regarding metabolic parameters, low-density lipoprotein-cholesterol levels decreased significantly ($P = 0.007$), and levels of glycated hemoglobin, alanine aminotransferase, and γ-glutamyl transferase decreased significantly (each $P < 0.05$). Holm method for sensitivity analysis of the metabolic parameters revealed that there were no significant changes, but there was a trend of improvement in LDL-C ($P = 0.056$). Univariate regression analysis showed that age, body mass index, and changes in all metabolic parameters were not associated with T-score improvement. These results indicated that eldecalcitol might affect lipid metabolism and other metabolic parameters. Larger, controlled prospective studies with prespecified endpoints are required to determine whether eldecalcitol affects lipid and other metabolic parameters.

Keywords: Eldecalcitol, postmenopausal osteoporosis, lipid metabolism

1. Introduction

Osteoporosis is characterized by decreased bone mass and disruption of bone architecture, which increases the risk of fragility fractures (*1*). Therapeutic agents for osteoporosis have been recently developed (*2*), one of which is eldecalcitol (1α, 25-dihydroxy-2β-[3-hydroxypropoxy] vitamin D3), the newest analog of activated vitamin D (*3*). Previously, activated vitamin D analogs, as well as dietary vitamin D, have been reported to have efficacy on metabolic functions, such as glucose intolerance, lipid profiles, and hepatic function, both *in vitro* and *in vivo*, as well as clinically (*4-17*). Among them, a recent clinical study highlighted that eldecalcitol can improve glucose tolerance (*14*). Meanwhile, the association between lipid profiles and eldecalcitol remains unclear, as few studies have previously investigated this relationship *in vitro* and *in vivo* (*18*). Besides, the effects of eldecalcitol on lipid profiles have not been clinically investigated in the literature. Therefore, in this real-world study, we aimed to investigate the effects of eldecalcitol on lipid profiles and other metabolic parameters in postmenopausal women with osteoporosis.

2. Patients and Methods

2.1. Ethical approval of the study protocol

This study was approved as a retrospective study by the Ethics Review Committee of Nagasaki Prefecture Iki Hospital (Nagasaki, Japan; approval number: 2016-02) and conducted in accordance with the principles of the Declaration of Helsinki. All the participants provided written informed consent for inclusion

2.2. Study participants

We recruited 54 postmenopausal female individuals who were first diagnosed with osteoporosis at Nagasaki Prefecture Iki Hospital between November 2016 and October 2018, who satisfied the diagnosis of osteoporosis in accordance with widely used criteria (*19*); who did not have endocrine diseases that affect bone mass, such as hyperparathyroidism, Cushing's syndrome, pheochromocytoma, primary aldosteronism, thyroid dysfunction, and other diseases; and whose drugs, except for eldecalcitol, were not changed during the study period. The complications were defined. Hypertension was defined as systolic blood pressure ≥ 140 mmHg and/or diastolic blood pressure ≥ 90 mmHg and/or the use of antihypertensive drugs. Diabetes mellitus was defined as any combination of fasting plasma glucose (FPG) level ≥ 126 mg/dL, random blood sugar level ≥ 200 mg/dL, glycated hemoglobin (HbA1c) level ≥ 6.5%, or use of antidiabetic agents. Dyslipidemia was defined as any combination of total cholesterol level ≥ 220 mg/dL, low-density lipoprotein-cholesterol (LDL-C) level ≥ 140 mg/dL, high-density lipoprotein-cholesterol (HDL-C) level < 40 mg/dL; triglyceride (TG) level ≥ 150 mg/dL, or use of lipid-lowering drugs (*20*). Participant characteristics, including their medical treatment, are shown in Table 1. 27 participants (50.0%) were receiving antihypertensive treatment, 3 (5.6%) were receiving antidiabetic treatment, and 21 (38.9%) were receiving treatment for dyslipidemia. Regarding their medications for dyslipidemia, all patients who received treatment for dyslipidemia were medicated with a statin, and four patients received ezetimibe in addition to a statin. Medications for dyslipidemia, hypertension, and diabetes mellitus, as well as other drugs, were not changed during the study period.

2.3. Methods and disease definitions

To examine the effects of eldecalcitol (0.75 μg per day), treatment was administered and continued for 24 weeks. The following variables were measured at baseline and 24 weeks after administration of eldecalcitol: parameters of lipid metabolism (LDL-C, HDL-C, and TG), glycemic parameters (FPG, HbA1c), and hepatic enzymes (aspartate aminotransferase [AST], alanine aminotransferase [ALT], gamma-glutamyl transferase [γ-GTP]). Blood samples were collected after overnight fasting. LDL-C, HDL-C, TG, FPG, AST, ALT, and γ-GTP concentrations were investigated using the enzymatic method. HbA1c was determined using a high-performance chromatographic method. Regarding the effects of eldecalcitol on osteoporosis, T-scores (lumbar spine and femoral neck) were measured at baseline and 24 weeks after eldecalcitol administration with dual-energy X-ray absorptiometry (DXA; Discovery A, Hologic Inc., Waltham, MA).

2.4. Statistical analyses

Data are presented as mean ± standard deviation (SD). Changes in laboratory measurements from baseline to 24 weeks were assessed using a paired *t*-test and Holm method for sensitivity analysis for the metabolic parameters. The associations between changes in T-scores (lumbar spine and femoral neck) and metabolic parameters were examined using univariate regression analyses. *P*-values < 0.05 were considered statistically significant. Statistical analyses were performed using Stata SE version 16 (StataCorp.2019. Stata Statistical Software, Release 16. College Station, TX: Stata Corp LLC.).

3. Results

The characteristics of the study participants are summarized in Table 1. All patients completed the study without any complications, including hypercalcemia and hypercalciuria. Regarding parameters of lipid metabolism, LDL-C and TG levels are decreased and HDL-C levels increased from baseline to 24 weeks after eldecalcitol administration; however, no statistical significance in a paired *t*-test was observed for HDL-C levels (LDL-C: 120.0 ± 24.5 *vs.* 113.9 ± 21.1 mg/dL, $P = 0.007$; HDL-C: 70.4 ± 15.1 *vs.* 71.2 ± 16.7 mg/dL, $P = 0.137$; TG: 111.7 ± 56.7 *vs.* 101.9 ± 49.8 mg/dL, $P = 0.057$).

Regarding glycemic parameters, HbA1c and FPG levels decreased from baseline to 24 weeks after eldecalcitol administration; however, no statistical significance in a paired *t*-test was observed for FPG levels (FPG: 100.5 ± 10.0 *vs.* 98.8 ± 9.2 mg/dL, $P = 0.132$; HbA1c: 5.84 ± 0.40 % *vs.* 5.78 ± 0.35 %, $P = 0.047$). Regarding hepatic enzymes, ALT, AST, and γ-GTP levels decreased from baseline to 24 weeks after eldecalcitol administration; however, no statistical significance in a paired *t*-test was observed for AST levels (AST: 21.7 ± 5.5 *vs.* 21.5 ± 4.6 U/L, $P = 0.382$; ALT: 17.4 ± 8.3 *vs.* 16.1 ± 5.5 U/L, $P = 0.037$; γ-GTP: 24.5 ± 20.0 *vs.* 21.3 ± 13.4 U/L, $P = 0.032$).

Holm method for sensitivity analysis for the metabolic parameters revealed that there were no significant changes from baseline to 24 weeks after eldecalcitol administration, but there was a trend of improvement in LDL-C ($P = 0.056$).

Regarding osteoporosis, the T-scores of the lumbar spine and femoral neck increased significantly from baseline to 24 weeks after administration of eldecalcitol (lumbar spine: − 1.97 ± 1.00 *vs.* − 1.84 ± 1.03, $P < 0.001$; femoral neck: − 2.67 ± 0.71 *vs.* − 2.48 ± 0.69, $P < 0.001$). All the changes in the parameters are shown in Table 2.

In addition, univariate regression analysis showed that age, body mass index, and improvements in all metabolic parameters were not associated with improvements in T-scores for both the lumbar spine and the femoral neck (Table 3).

Table 1. Characteristics of the patients in our study cohort

	n = 54
Age (years)	67.4 ± 7.2
BMI (kg/m^2)	22.3 ± 3.5
LDL-C (mg/dL)	120.0 ± 24.5
HDL-C (mg/dL)	70.4 ± 15.1
TG (mg/dL)	111.7 ± 56.7
FPG (mg/dL)	100.5 ± 10.0
HbA1c (%)	5.84 ± 0.40
AST (U/L)	21.7 ± 5.5
ALT (U/L)	17.4 ± 8.3
γ-GTP (U/L)	24.5 ± 20.0
P I NP (ng/mL)	45.4 ± 11.9
TRACP-5b (mU/dL)	495.6 ± 177.2
T-score (lumbar spine)	−1.97 ± 1.00
T-score (femoral neck)	−2.67 ± 0.71
Morbidity of hypertension	29 (53.7%)
Medical treatment for hypertension	27 (50.0%)
Administration of Ca blocker	24 (44.4%)
Administration of ACE inhibitor	3 (5.6%)
Administration of ARB	21 (38.9%)
Administration of beta-blocker	6 (11.1%)
Administration of thiazide derivative	3 (5.6%)
Morbidity of diabetes mellitus	10 (18.5%)
Medical treatment for diabetes mellitus	3 (5.6%)
Administration of DPP4 inhibitor	3 (5.6%)
Administration of biguanide	2 (3.7%)
Morbidity of dyslipidemia	29 (53.7%)
Medical treatment for dyslipidemia	21 (38.9%)
Administration of statin	21 (38.9%)
Administration of ezetimibe	4 (7.4%)

Data are presented as mean ± standard deviation (SD). ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; AST, aspartate aminotransferase; ALT, alanine aminotransferase; BMI, body mass index; DPP4, dipeptidyl deptidase-4; FPG, fasting plasma glucose; γ-GTP, γ-glutamyl transferase; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; P I NP, type I procollagen N-terminal propeptide; SD, standard deviation; TG, triglyceride; TRACP-5b: tartrate-resistant acid phosphatase-5b.

4. Discussion

Eldecalcitol is the newest analog of activated vitamin D that can improve osteoporosis by facilitating bone formation and inhibiting bone resorption (*21*). The effects of eldecalcitol on osteoporosis have been revealed in clinical trials, and it has been approved for the treatment of osteoporosis (*22*). Previous *in vitro* and *in vivo* studies have demonstrated that dietary vitamin D can improve glucose tolerance, lipid profiles, and hepatic function (*4-6*). Clinical studies have also reported these efficacy (*6-9*). Previous *in vitro* and *in vivo* studies also showed that calcitriol, one of the activated vitamin D analogs, can improve glucose tolerance and hepatic function (*6,10,11*). In addition, the recent clinical study indicated that calcitriol improved hepatic dysfunction in patients with non-alcoholic fatty liver (*13*). Regarding eldecalcitol, Kawahara *et al.* reported that eldecalcitol can improve glucose tolerance and reduce the development of type 2 diabetes *via* both increased insulin secretion and reduced insulin resistance in a double-blind, multicenter, randomized, placebo-controlled study (*14*). In terms of hyperlipidemia, it was reported that activated vitamin D ameliorated AMPK/SIRT1 activity *in vitro* (*15*). Improvement of both AMPK and SIRT1 was known to improve hyperlipidemia (*16,17*). These results indicated that activated vitamin D analogs can improve lipid metabolism. However, the effect of eldecalcitol on lipid profiles remains unclear.

In the present study, regarding the glucose tolerance of the patients, a small decrease in HbA1c was observed. Regarding hepatic function, ALT and γ-GTP

Table 2. Metabolic parameters and T-scores at baseline and 24 weeks after eldecalcitol administration in the study cohort

	Baseline	24 weeks after	Mean paired change (95% CI)	*P*	*P* (Holm-adjusted)
LDL-C (mg/dL)	120.0 ± 24.5	113.9 ± 21.1	6.17 (1.33-11.00)	0.007*	0.056
HDL-C (mg/dL)	70.4 ± 15.1	71.2 ± 16.7	-1.26 (-3.55-1.03)	0.137	0.224
TG (mg/dL)	111.7 ± 56.7	101.9 ± 49.8	9.89 (-2.43-22.21)	0.057	0.228
FPG (mg/dL)	100.5 ± 10.0	98.8 ± 9.2	1.76 (-1.37-4.89)	0.132	0.528
HbA1c (%)	5.84 ± 0.40	5.78 ± 0.35	0.06 (-0.01-0.13)	0.047*	0.235
AST (U/L)	21.7 ± 5.5	21.5 ± 4.6	0.17 (-0.94-1.27)	0.382	0.382
ALT (U/L)	17.4 ± 8.3	16.1 ± 5.5	1.31 (-0.13-2.76)	0.037*	0.222
γ-GTP (U/L)	24.5 ± 20.0	21.3 ± 13.4	3.15 (-0.18-6.48)	0.032*	0.224
T-score (lumbar spine)	-1.97 ± 1.00	-1.84 ± 1.03	0.14 (0.08-0.20)	< 0.001*	-
T-score (femoral neck)	-2.67 ± 0.71	-2.48 ± 0.69	0.19 (0.10-0.29)	< 0.001*	-

Data are presented as mean ± SD (values at baseline and 24 weeks after). *P*-values were calculated using a paired *t*-test. P-values (Holm-adjusted) were calculated using the Holm method for sensitivity analysis of the metabolic parameters. $P < 0.05$ was considered significant (*). AST, aspartate aminotransferase; ALT, alanine aminotransferase; BMI, body mass index; CI, confidence interval; FPG, fasting plasma glucose; γ-GTP, γ-glutamyl transferase; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SD, standard deviation; TG, triglyceride.

Table 3. Association between improvement in T-scores (lumbar spine and femoral neck) and improvement in metabolic parameter findings

Regression analysis	Improvement in T-score (lumbar spine)			Improvement in T-score (femoral neck)		
	β (SE)	95% CI	*P*	β (SE)	95% CI	*P*
Age	0.002 (0.004)	-0.006-0.011	0.624	0.002 (0.004)	-0.006-0.011	0.624
BMI	-0.000 (0.000)	-0.001-0.001	0.476	-0.000 (0.000)	-0.001-0.001	0.476
Improvement in LDL-C (mg/dL)	0.001 (0.002)	-0.003-0.004	0.669	0.001 (0.002)	-0.003-0.004	0.669
Improvement in HDL-C (mg/dL)	0.001 (0.004)	-0.006-0.008	0.796	0.001 (0.004)	-0.006-0.008	0.796
Improvement in TG (mg/dL)	-0.000 (0.001)	-0.001-0.001	0.907	-0.000 (0.001)	-0.001-0.001	0.907
Improvement in FPG (mg/dL)	-0.004 (0.003)	-0.009-0.001	0.149	-0.004 (0.003)	-0.009-0.001	0.149
Improvement in HbA1c (%)	-0.127 (0.657)	-0.356-0.102	0.271	-0.127 (0.657)	-0.356-0.102	0.271
Improvement in AST (U/L)	-0.008 (0.007)	-0.023-0.007	0.309	-0.008 (0.007)	-0.023-0.007	0.309
Improvement in ALT (U/L)	-0.000 (0.006)	-0.012-0.011	0.936	-0.000 (0.006)	-0.012-0.011	0.936
Improvement in γ-GTP (U/L)	0.001 (0.002)	-0.004-0.006	0.601	0.001 (0.002)	-0.004-0.006	0.601

$P < 0.05$ was considered significant. AST, aspartate aminotransferase; ALT, alanine aminotransferase; β, regression coefficient; BMI, body mass index; CI, confidence interval; FPG, fasting plasma glucose; γ-GTP, γ-glutamyl transferase; HbA1c, glycated hemoglobin; HDL-C, high-density lipoprotein cholesterol; LDL-C, low-density lipoprotein cholesterol; SE, standard error; TG, triglyceride.

decreased during the treatment period. Regarding lipid metabolism, the levels of LDL-C decreased from before to 24 weeks after eldecalcitol administration. The change was significant by a paired *t*-test and was a trend by Holm method for sensitivity analysis. However, the clinical significance is uncertain. Statistical significance did not necessarily imply clinical relevance. In particular, although HbA1c showed a nominally significant decrease, the absolute mean change was only approximately 0.06% and its clinical significance is uncertain. Similar caution has been applied to the changes in the other metabolic parameters. Besides, the evaluation of glycemic parameters was performed only for the values of FPG and HbA1c, and that of liver function only for the values of AST/ALT/γ-GTP. Furthermore, changes in diet, physical activity, body weight, adherence to concomitant medications, regression to the mean, and other time-related factors were not investigated. They could have contributed to the observed changes. In addition, no statistically significant association was observed between changes in the measured metabolic parameters and changes in T-scores in the present study. Given the small sample size and exploratory nature of these analyses, the relationship between these changes remains uncertain and requires further investigation.

In this single-center study of 54 osteoporosis-treatment-naïve postmenopausal women with osteoporosis, small decreases in LDL-C, HbA1c, ALT, and γ-GTP were observed during 24 weeks of eldecalcitol treatment. However, these metabolic findings did not remain statistically significant after adjustment for multiple comparisons and should be considered exploratory. Because the present study was a single-center, single-arm retrospective study without a control group, a causal effect of eldecalcitol could not be established. Larger, controlled prospective studies with prespecified endpoints are required to determine whether eldecalcitol affects lipid and other metabolic parameters.

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References

1. Raisz LG. Pathogenesis of osteoporosis: concepts, conflicts, and prospects. J Clin Invest. 2005; 115:3318-3325.
2. Langdahl BL. Overview of treatment approaches to osteoporosis. Br J Pharmacol. 2021; 178:1891-1906.
3. Sanford M, McCormack PL. Eldecalcitol: a review of its use in the treatment of osteoporosis. Drugs. 2011; 71:1755-1770.
4. Hochrath K, Stokes CS, Geisel J, Pollheimer MJ, Fickert P, Dooley S, Lammert F. Vitamin D modulates biliary fibrosis in ABCB4-deficient mice. Hepatol Int. 2014; 8:443-452.
5. Enciso PL, Wang L, Kawahara Y, Sakamoto S, Shimada S, Takeichi Y, Takayanagi R, Nomura M. Dietary vitamin D3 improves postprandial hyperglycemia in aged mice. Biochem Biophys Res Commun. 2015; 461:165-171.
6. Du T, Xiang L, Zhang J, Yang C, Zhao W, Li J, Zhou Y, Ma L. Vitamin D improves hepatic steatosis in NAFLD *via* regulation of fatty acid uptake and beta-oxidation. Front Endocrinol (Lausanne). 2023; 14:1138078.
7. Zhang W, Yi J, Liu D, Wang Y, Jamilian P, Gaman MA, Prabahar K, Fan J. The effect of vitamin D on the lipid profile as a risk factor for coronary heart disease in postmenopausal women: a meta-analysis and systematic review of randomized controlled trials. Exp Gerontol. 2022; 161:111709.
8. Dutta D, Mondal SA, Choudhuri S, Maisnam I, Hasanoor Reza AH, Bhattacharya B, Chowdhury S, Mukhopadhyay S. Vitamin-D supplementation in prediabetes reduced progression to type 2 diabetes and was associated with

decreased insulin resistance and systemic inflammation: an open label randomized prospective study from Eastern India. Diabetes Res Clin Pract. 2014; 103:e18-e23.
9. Hussain M, Iqbal J, Malik SA, Waheed A, Shabnum S, Akhtar L, Saeed H. Effect of vitamin D supplementation on various parameters in non-alcoholic fatty liver disease patients. Pak J Pharm Sci. 2019; 32:1343-1348.
10. Zhou QG, Hou FF, Guo ZJ, Liang M, Wang GB, Zhang X.1,25-Dihydroxyvitamin D improved the free fatty-acid-induced insulin resistance in cultured C2C12 cells. Diabetes Metab Res Rev. 2008; 24:459-464.
11. Chou CL, Pang CY, Lee TJ, Fang TC. Beneficial effects of calcitriol on hypertension, glucose intolerance, impairment of endothelium-dependent vascular relaxation, and visceral adiposity in fructose-fed hypertensive rats. PLoS One. 2015;10:e0119843.
12. Su D, Nie Y, Zhu A, *et al.* Vitamin D Signaling through Induction of Paneth Cell Defensins Maintains Gut Microbiota and Improves Metabolic Disorders and Hepatic Steatosis in Animal Models. Front Physiol. 2016; 7:498.
13. Yaghooti H, Ghanavati F, Seyedian SS, Cheraghian B, Mohammadtaghvaei N. The efficacy of calcitriol treatment in non-alcoholic fatty liver patients with different genotypes of vitamin D receptor FokI polymorphism. BMC Pharmacol Toxicol. 2021; 22:18.
14. Kawahara T, Suzuki G, Mizuno S, Inazu T, Kasagi F, Kawahara C, Okada Y, Tanaka Y. Effect of active vitamin D treatment on development of type 2 diabetes: DPVD randomized controlled trial in Japanese population. BMJ. 2022; 377:e066222.
15. Chang E, Kim Y. Vitamin D Ameliorates Fat Accumulation with AMPK/SIRT1 Activity in C2C12 Skeletal Muscle Cells. Nutrients. 2019; 11:2806.
16. Luo Z, Zang M, Guo W. AMPK as a metabolic tumor suppressor: control of metabolism and cell growth. Future Oncol 2010; 6:457-470.
17. Lu C, Zhao H, Liu Y, Yang Z, Yao H, Liu T, Gou T, Wang L, Zhang J, Tian Y, Yang Y, Zhang H. Novel Role of the SIRT1 in Endocrine and Metabolic Diseases. Int J Biol Sci. 2023; 19:484-501.
18. Jiang Y, Gao R, Ying Q, Li X, Dai Y, Song A, Liu H, Hasegawa T, Li M. Eldecalcitol ameliorates diabetic osteoporosis and glucolipid metabolic disorder by promoting Treg cell differentiation through SOCE. Cell Mol Life Sci. 2024; 81:423.
19. Soen S, Fukunaga M, Sugimoto T, Sone T, Fujiwara S, Endo N, Gorai I, Shiraki M, Hagino H, Hosoi T, Ohta H, Yoneda T, Tomomitsu T; Japanese Society for Bone and Mineral Research and Japan Osteoporosis Society Joint Review Committee for the Revision of the Diagnostic Criteria for Primary Osteoporosis. Diagnostic criteria for primary osteoporosis: year 2012 revision. J Bone Miner Metab. 2013; 31:247-257.
20. Abe I, Ochi K, Takashi Y, Yamao Y, Ohishi H, Fujii H, Minezaki M, Sugimoto K, Kudo T, Abe M, Ohnishi Y, Mukoubara S, Kobayashi K. Effect of denosumab, a human monoclonal antibody of receptor activator of nuclear factor kappa-B ligand (RANKL), upon glycemic and metabolic parameters: Effect of denosumab on glycemic parameters. Medicine (Baltimore). 2019; 98:e18067.
21. Matsumoto T, Takano T, Yamakido S, Takahashi F, Tsuji N. Comparison of the effects of eldecalcitol and alfacalcidol on bone and calcium metabolism. J Steroid Biochem Mol Biol. 2010; 121:261-264.
22. Matsumoto T, Endo I. Eldecalcitol for the treatment of osteoporosis. Drugs Today (Barc). 2012; 48:189-196.

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